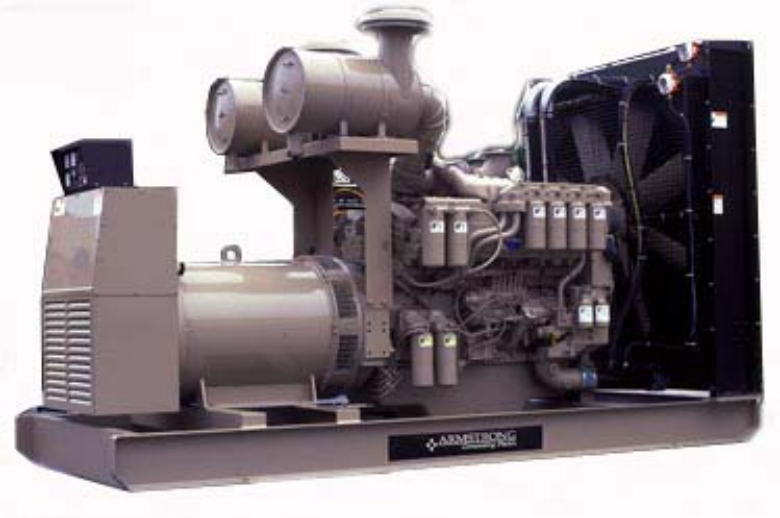
ARMSTRONG POWER SYSTEMS

Date: 10/01/07

# OWNERS MANUAL

## CUMMINS SERIES:

**MODELS ACUM65, ACUM84, ACUM110, ACUM140, ACUM185, ACUM210**





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## SAVE THESE INSTRUCTIONS

This manual contains important instructions regarding for all Armstrong Power Systems LLC power generator Models. The information contained here must be followed during installation and maintenance of the generator and batteries. Keep this manual with the equipment. If the equipment is traded or sold, give the manual to the new owner.

You are now the owner of a Armstrong Power generator powered by CUMMINS engine. All our components keep the highest standards in quality, efficiency and durability.

Each unit pass thru  a complete test and inspection to guarantee the quality of your unit. We provide warranty on every component subject to the warranty coverage and limitations.

To get the best results from your new generator please read carefully this document before starting the unit and follow the instructions.

If you have any question regarding your equipment please call your dealer or contact us. Please have the generator model, and serial numbers when you call. Parts may be obtained directly from our distributors.

Once again thank you for your trust in Armstrong Power and welcome to our family.



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# ARMSTRONG POWER SYSTEMS

# WARRANTY CERTIFICATE

The warranty period for the power generator begins on the date of sale and continues for a period of 2 years or 1500 hours (what ever comes first).

**Responsibilities: a)** As the owner, you are responsible for the performance of the required maintenance listed on your operators manual. **b)** Armstrong Power may deny your warranty coverage if your engine or part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

**Coverage:** Armstrong Power warrants that your unit shall be free from defects in materials and workmanship which cause the unit to fail. During the period mentioned above from the date of the original sale.

**Limitations:** this warranty certificate shall not cover any of the following. **a)** Repair or replacement required because of misuse or neglect, improper maintenance, repairs improperly performed or replacements not conforming to Armstrong Power specifications that adversely affect performance and/or durability, and alteration or modifications not recommended or approved in writing by Armstrong Power. **b)** Replacement of parts and other services and adjustments necessary for required maintenance at and after the first scheduled replacement point.

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# IMPORTANT SAFETY INSTRUCTIONS



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# 1. INTRODUCTION

This manual provides general safety information for installing, operating and maintenance of Armstrong Power equipments. The purchaser should comply with the instructions and information in this manual, and is strongly advised that all personnel to be associated with the equipment supplied should be made familiar with the information contained herein.

It is essential that the personnel engaged in the installation, commissioning and maintenance of this equipment are both competent and experienced in these fields, and that they comply with the relevant statutory requirements and regulations, including he provisions of the Health and Safety act 1974, and any such modifications and amendments which may subsequently become a legal requirement.

The equipment supplied by Armstrong Power should be installed by, or under the supervision of, competent personnel in accordance with good engineering practice, established codes of practice, those statutory requirements applicable to the installation site, the IEE regulations as applicable and, where the appropriate, in accordance with any instructions specifically advised by the company.

You are requested, in accordance with the needs of safe operation and the provisions of the act, to take such steps as are necessary to ensure that the appropriate information on the proper use and handling of our equipment is made available by yourself to all those concerned. Similarly, this information must be available to anyone who may purchase, or otherwise acquire from your self, such products for use in their own premises.

# 2. GENERAL

The generating set is designed to be safe when used in the correct manner. The following safety precautions, if followed will minimize the possibility of accidents. Before performing any procedure or operating technique, it is up to the user to ensure that it's safe. The generating set should only be operated by personnel who are authorized and trained.

## Warning:

- Read and understand all safety precautions, and warnings before operating the generating set.
- Failure to follow the instructions, procedures and safety precautions in this manual may increase the possibility of accidents and injuries.
- Never start the generating set unless it is safe to do so.
- Do not attempt to operate the generating set with a know unsafe condition.
- If the generating set is unsafe, fit danger notices and disconnect the battery negative (-) lead so that it cannot be started until the condition is corrected.
- Disconnect the battery negative (-)lead prior to attempting any repairs or cleaning inside the enclosure, if equipped.
- Appropriate firefighting equipment is to hand.
- The metal work on every part of the generating set must be connected by means of an earth continuity conductor to an effective earth point.
- Care must be taken to avoid spillage from the batteries.
- No loose items or combustible material should be left on or against any part of the generator.
- Do not risk injury by coming into contact with moving parts of the plant, or by allowing anything to be draw in by the cooling fan or intake system.
- Install and operate this generating set only in full compliance with relevant National, local or federal codes, standards or other requirements.



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## 3. FIRE AND EXPLOSION

### Risk of serious injuries or death

Fuels and fumes associated with generating sets can be flammable and potentially explosive. Proper care in handling these materials can dramatically limit the risk of fire or explosion. However, safety dictates that fully charged BC and ABC fire extinguishers are kept on hand. Personnel must know how to operate them.

- The acids in the battery can cause explosion.
- Avoid any contact between the tools and the terminals in the battery.
- Never use metallic objects on the neck or hands when handling the set.
    - Never connect the negative terminal from the battery to the positive terminal from the starter.
    - Don't smoke or allow sparks, flames or other sources of ignition around the fuel or batteries.
- Use adequate equipment to take fuel from the set.
- Never test the battery by touching together the terminals.
- Ensure the generating set room is properly ventilated.
- Don't touch the battery charger or the connections during the battery charging process.
- Always disconnect the negative terminal from the battery before to start any work on the unit.
- Keep the room, the floor and the generating set clean. When spills of fuel, oil, battery electrolyte or coolant occur they should be cleaned up immediately.
- Never store flammable liquids near the engine.
- Store oily rags in covered metal containers.
- Avoid refilling the fuel tank while the engine is running.
- Do not attempt to operate the generating set with any known leaks in the fuel system.

## 4. INSTALLATION, HANDLING AND TOWING

- Make electrical connections in compliance with relevant electrical codes, standards or other requirements. This includes requirements for grounding and ground/earth faults.
- For stationary generating sets with remote fuel storage systems, make sure such systems are installed in compliance with relevant codes, standards or other requirements.
- Engine exhaust emissions are hazardous to personnel. The exhaust for all indoor generating sets must be piped outdoors via leak-free piping in compliance with relevant codes, standards and other requirements. Ensure hot exhaust silencers, piping and turbochargers, if equipped, are clear of combustible material and are guarded for personnel protection per safety requirements. Ensure that fumes from the exhaust outlet will not be hazard.
- Never lift the generating set by attaching to the engine or alternator lifting lugs. Use a sling with a "spreader bar" connected to the base frame.
- Ensure the lifting rigging and supporting structure is in good condition and has capacity suitable for the load.
- Keep all personnel away from the generating set when it is suspended.
- Make sure all personnel are out of the generating set canopy or container, if equipped, before closing and latching enclosure doors.
- When towing a mobile generating set, observe all codes, standards or other regulations and traffic laws. These include those regulations specifying required equipment and maximum and minimum speeds. Ensure brakes, if fitted, are in good order.
- Do not permit personnel to ride in or on the mobile generating set. Do not permit personnel to stand or ride on the drawbar or to stand or walk between the generating set and the towing vehicle.
- Do not install or use the generating set in any classification of hazardous environment unless it has been specifically designed for that environment.



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## 5. MECHANICAL

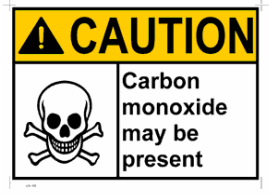
The generating set is designed with guards for protection from moving parts. Care must still be taken to protect personnel and equipment from other mechanical hazards when working around the generating set.

- Do not attempt to operate the generating set with safety guards removed. While the generating set is running do not attempt to reach under or around the guards to do maintenance or for any other reason.
- Keep hands, arms, long hair, loose clothing and jewellery away from pul-leys, belts and other moving parts.

**Attention!! Some moving parts con not be seen clearly when the set is running.**

- Keep access doors on enclosures, if equipped, closed and locked when not required to be open.
- Avoid contact with hot oil, hot coolant, hot exhaust gases, hot surfaces and sharp edges and corners.
- Wear protective clotting including gloves and hat when working around the generating set.
- Do not attempt to remove the radiator filler cap until the coolant has cooled. Then loosen the cap slowly to relive any excess pressure before removing the cap completely.
- Ethyl ether starting aids **must not** be used on engines with combustion air preheating devises. These starting aids will reduce the efficient working life of the engine.

## 6. CHEMICAL




Fuels, oils coolants, lubricants and battery electrolyte used in this generating set are typical of the industry. However they can be hazardous to personnel if not treated properly.

- Do not swallow or have skin contact with fuel, oil, coolant, lubricants and battery electrolyte. If swallowed, seek medical treatment immediately. Do not induce vomiting if fuel is swallowed. For skin contact, wash with soap and water.
- Do not wear clothe that has been contaminated by fuel or lube oil.
- Wear an acid resistant apron and face shield or goggles when servicing the battery. If electrolyte is spilled on skin or clotting, flush immediately with large quantities of water.
- Always keep good ventilation when the equipment is working. Carbon Monoxide inhalation cause death. Always maintain inspection routine of the exhaust system.



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## 7. NOISE

Generating sets that are not equipped with sound attenuating enclosures can produce noise levels in excess of 105 dBA. Prolonged exposure to noise levels above 85 dBA is hazardous to hearing.

- Ear protection must be worn when operating or working around an operating set.

## 8. ELECTRICAL

Safe and efficient operation of electrical equipment can be achieved only if the equipment is correctly installed, operated and maintained.

- The generating set must be connected to the load only by trained and qualified electricians who are authorized to do so, and in compliance with relevant electric codes, standards and other regulations.
- Ensure the generating set, is effectively grounded/earthed in accordance with all relevant regulations prior operation.
- The generating sets should be shutdown with the battery negative (-) terminal disconnected prior to attempting to connect or disconnect load connections.
- Do not attempt to connect or disconnect load connections while standing in water or on wet or soggy ground.
- Do not touch electrical energized parts of the generating set and/or interconnecting cables or conductors with any part of the body or with any non insulated conductive object.
- Place the control panel cover as soon as connection or disconnection of the load cables is complete. **Do not** operate the generating set without the cover securely on place.
- Connect the generating set only to loads and/or electrical systems that are compatible with it's electrical characteristics and that are within it's rated capacity.
- Be sure all power is disconnected from the electrical equipment being serviced.
- Keep all electrical equipment clean and dry. Replace any wiring where the insulation is cracked, cut, abraded or otherwise degraded. Replace terminals that are worm, discolored or corrode. Keep terminals clean and tight.
- Insulate all connections and disconnected wires.
- Use only class BC or Class ABC extinguishers on electrical fires.



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# 9. FIRST AID FOR ELECTRIC SHOCK

Identification / look out for:

- Unconsciousness and Burns
- Establish site of entry and exit of electric shock

**What to do:**

- Switch off the main switch.
- Break the contact between electrical source and patient using dry non-conductive object like wooden stick.
- Call for help.
- If breathing and heartbeat has stopped begin CPR

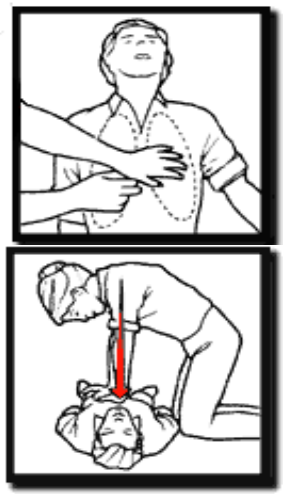
**1. CALL**

Check the victim for unresponsiveness. If there is no response, Call 911 and return to the victim. In most locations the emergency dispatcher can assist you with CPR instructions.

**2. BLOW**

Tilt the head back and listen for breathing. If not breathing normally, pinch nose and cover the mouth with yours and blow until you see the chest rise. Give 2 breaths. Each breath should take 1 seconds.

**3. PUMP**



If the victim is still not breathing normally, coughing or moving, begin chest compressions. Push down on the chest 11/2 to 2 inches 30 times right between the nipples. Pump at the rate of 100/minute, faster than once per second.
CONTINUE WITH 2 BREATHS AND 30 PUMPS UNTIL HELP ARRIVES.

In unconscious patient with intact breathing and pulse recovery position ensures the prevention of tongue falling back and blocking the airway.

**What to do:**

- Place the patient on their back.
- Lift the chin to ensure the air way is open.
  - Patient's arm on your side should be positioned so as to make a right angle with his body, with elbow bent and palm facing out.
  - Patient's other arm on opposite side should be placed across the chest, with back of their hand against the cheek on your side of the patient.
  - Pull up the patient's knee joint (side away from you) as it bends with the foot flat on the ground.
- Roll over the patient in this position towards your side.
- By tilting the patient's head back ensure that the airway is open.



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## 10. SPECIAL CONSIDERATIONS FOR BATTERY

**CAUTION** – The electrolyte is a dilute sulfuric acid that is harmful to the skin and eyes. It is electrically conductive and corrosive. The following procedures are to be observed:

1) Wear full eye protection and protective clothing,
2) Where electrolyte contacts the skin, wash it off immediately with water,
3) Where electrolyte contacts the eyes, flush thoroughly and immediately with water and seek medical attention, and
4) Spilled electrolyte is to be washed down with an acid neutralizing agent. A common practice is to use a solution of one pound (500 grams) bicarbonate of soda to one gallon (4 liters) of water. The bicarbonate of soda solution is to be added until the evidence of reaction (foaming) has ceased. The resulting liquid is to be flushed with water and the area dried.

**CAUTION** – Lead-acid batteries present a risk of fire because they generate hydrogen gas. The following procedures are to be followed:

1) DO NOT SMOKE when near batteries,
2) DO NOT cause flame or spark in battery area, and
3) Discharge static electricity from body before touching batteries by first touching a grounded metal surface.



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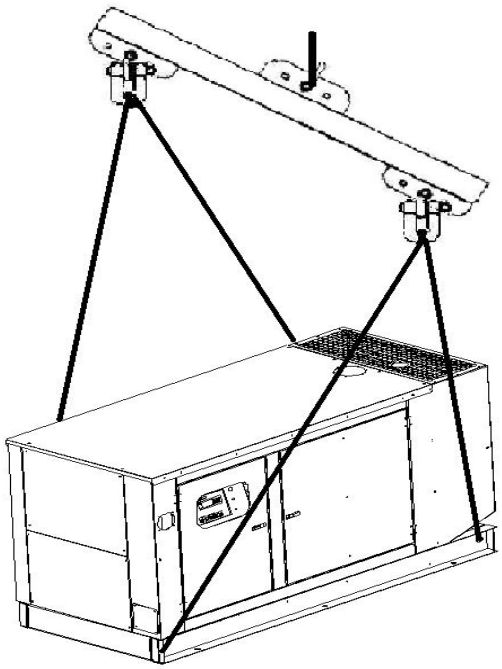
# GENERATING SET INSTALLATION





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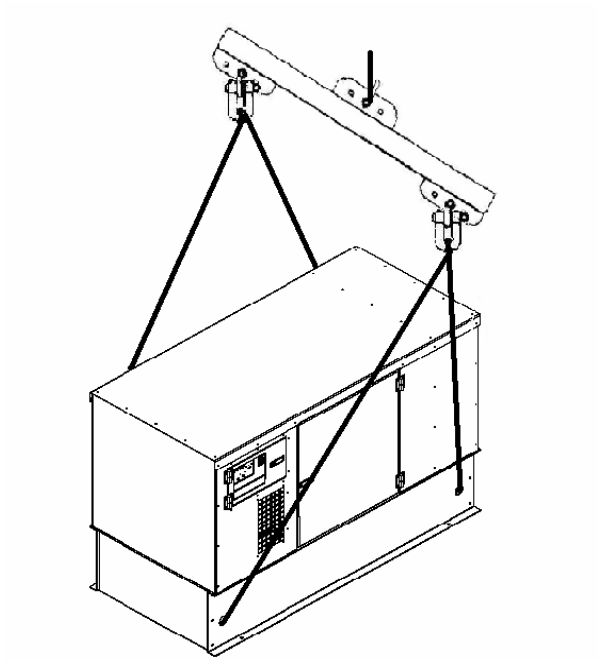
# 1. LOCATION

The generating set sub base tank or frame (if it's the case) is specifically designed for ease of moving the set. Improper handling can cause serious damage to the generator and components.
Never lift the generating set by attaching lugs to the engine or alternator. Shackles and chains of suitable length and lifting capacity must be used. A spreader bar is required to prevent damaging the set.



See the drawings:

The location for a generator is dependent on applicable codes and associated support systems for the generator such as ventilation, wiring, fuel, and exhaust.

The following factors should be considered:

- The ideal location for any generator is away from extreme ambient temperatures and where the generator is protected from adverse weather conditions. It is recommended that generator be as close to the load it is supporting as possible.
- The structure where the Generator Set will be set upon must be strong enough to support the weight of the Gen-Set, its' auxiliary equipment, and other equipment mounted on the structure.
- The structure must meet a 1 hour non-combustion fire rating.
- The installation site must be clean, dry and not subject to flooding.
- Because of excessive ambient temperatures associated with the use of stand-alone metal sheds from exposure to sunlight, a concrete pad with a supported roof and an outside security enclosure (fence) to protect the unit from vandalism, birds, rodents, and other small animals is recommended.
- The Gen-Set generates heat while running. Installing the Gen-Set in a tightly enclosed building or shed is not recommended. The site must provide for adequate cooling and ventilation with a minimum of duct work. Adequate ventilation for a generator is specified in cubic feet per minute.
- The site must permit engine exhaust gases to be piped away to an area that is uninhabited by people or animals. Care must be given to ensure that exhaust gases do not re-enter an occupied area.
- The outside site must provide access to the generator to allow for maintenance, service, and repair. A three foot (.914 meter) service clearance around the unit is recommended.
- Fuel supply and ease of refueling must be taken into consideration.
- Adequate normal and emergency lighting must be provided in any installation.

## 1.1. GROUND/FLOOR LOADING

The foundation for the generator must support the total weight of the generator. This includes fuel, oil, and the weight of any associated support systems.

Plan for 3 feet (1 Meters) of access around the generator for maintenance, service and repair.

When calculating the floor loading, ensure the fuel weight, cooling system fluids (where applicable), piping, pumps, power cables/runways and supporting structures are included in the calculations.

# 2. MOUNTING

A concrete foundation with anchored mounting bolts, is recommended. Steel Beams are an acceptable alternative. Foundations help in the servicing and repair of Gen-Set's and protect the unit from moisture that could occur from seepage. The concrete base that the generator is mounted to should be separate and independent from the surrounding structure.

The following applies to concrete bases:

A Single (See Figure 1)or Double (See Figure 2) pedestal base may be used. A height of at least 6 inches higher than floor level is recommended.



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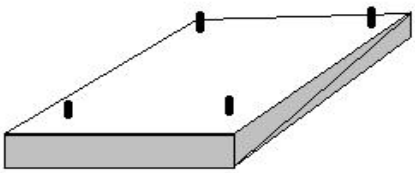
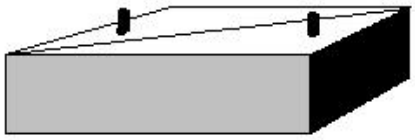
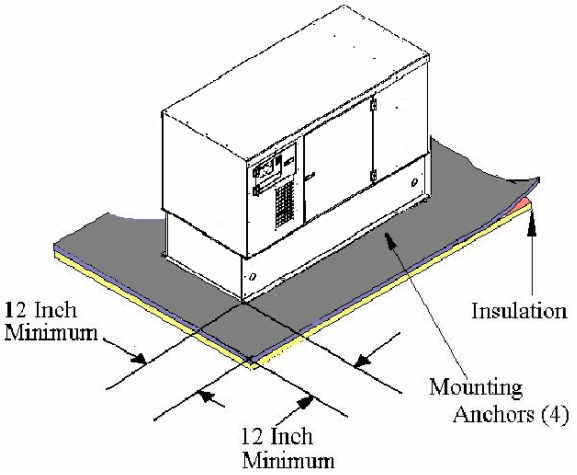


Figure 1- Single Pedestal Concrete Mount

Figure 2 - Double Pedestal Concrete Mount



- A double pedestal base allows easier cleaning under most generator's.
- Double pedestals provide better access for inspecting for oil or fuel tank leaks.
- The generator should be retained to the pedestal base with fasteners that are recommended by the generator set manufacturer.
- The concrete base should extend beyond the generator's "Footprint" by at least 12 Inches (305 mm) on all sides.
- The higher the mounting base is made, the easier the unit will be to work on when performing maintenance, service, or repairs. Typically bases are required to be raised at least 6 inches (153 mm) above floor level. Placing the unit higher than 6 inches sometimes has the advantage of making it easier to change the unit's oil.
- Passing fuel lines and electrical conduit for a "stub-up" through the concrete base is a standard practice of gen-set installers.
- Concrete foundations are typically mixed by volume. The typical ratio of cement, sand, and aggregate is 1:2:3 with a maximum 4 inch (102 mm) slump and 28 day compressive strength of 2500 psi (173 kPa).
- A generator can typically be mounted to a combustible floor or roof, dependent upon code, however, the surface beneath the engine and beyond the engine to a minimum distance of 12 inches (305 mm) must be covered with a non combustible insulation and a minimum of 24 gage sheet metal between the insulation




and the generator. See Figure 3.

Figure 3. Combustible Floor and Roof

- Optional vibration isolators beyond those already built in the generator also help reduce transmitted noise, however, it is recommended that one verify that the generator manufacturer recommends the use of an isolator.
- Insulation must be a non-combustible material, typically a Fiberglas mat.

## 3. VENTILATION

### 3.1. OUTDOOR INSTALLATIONS - AIR COOLED UNITS

If your generator is expected to be in temperatures lower than -20°F(-29°C) a cold weather package may be required.

The following general rules apply:

- Where strong prevailing winds are anticipated, face the engine end away from the wind.
- Plan the installation carefully to prevent the cooling air vents on the generator from becoming clogged by leaves, grass, snow, etc.



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## 4. ELECTRICAL SYSTEM

There are a number of different generator systems and typical loads in the context of electrical systems. Most systems, unless they contain automated switch gear, have a means of disconnect between the generator and the load. This is typically a transfer switch or disconnect. Ensure the contacts on the switch are rated for the size of your system.

### 4.1. GENERAL ELECTRICAL SYSTEM

When mounting electrical panels, a 3 foot clearance is required and the use of an emergency light to illuminate the unit during operation is typically required. Power for the emergency light should be from both the primary utility and the generator. This is highly recommend so that in the event of a malfunction there is a light source to see to work on the unit. Refer to your local building and electrical codes to ensure compliance.

### 4.2. CONDUCTOR SIZING CONNECTION

This information is dependent upon your generator output and intended load. When connecting cables to the generator, make connections at the generator first. Make the connections at the load last. Failure to do so may constitute a fire or safety hazard.

All ampacities are typically calculated at 75 ° C (Celsius) (167 ° F(Fahrenheit) in the conductor size charts. Building wire conductors should be rated at 90°C(194°F) to allow for different ambient temperatures that these conductors may pass through.

All conductors are typically required by electrical code to be copper. The recommended conductor sizes are based on maximum current. Ampacities are found in NEC Article 310, Table 310-16. Conductor resistances are found in NEC Table 8 "Conductor Properties".

### 4.3. CONNECTING THE GENERATOR

Please the refer to the electrical drawing of the unit and your transfer switch documentation for information related.

Leave the installation only to a trained personnel and don't forget to observe the local laws and permit requirements.

Errors during the installation may damage the equipment and electrical devices connected to the unit and may create fire and electrocution risks.

## 5. EXHAUST SYSTEM

### 5.1. GENERAL (EXHAUST SYSTEM)

Generator engines give off deadly carbon monoxide gas through their exhaust systems.
Carbon monoxide gas, if breathed in sufficient concentrations, can cause unconsciousness or death. Exhaust gases must be piped safely away from any room or enclosure that houses a generator and to a well ventilated area where people will not be endangered.
Besides the possibility of carbon monoxide poisoning, exhaust piping becomes extremely hot during operation and remains hot for a long time after shutdown. For that reason, the following precautions are necessary:

- Avoid contact with hot engines, exhaust manifolds, exhaust piping and mufflers. Any of these can cause severe burns.
- Where piping must pass through combustible walls or ceilings, special precautions must be taken to prevent fire or heat damage such as using heat thimbles through walls and ceilings.

### 5.2. GENERAL RULES FOR EXHAUST SYSTEM

When installing an exhaust system for a generator, the following rules should be considered:

- Exhaust piping should be of wrought iron or steel having adequate strength and durability.
- Exhaust fittings may be of cast iron. A 9 inch spacing (10 inches (250mm) recommended) from the exhaust pipe and walls is also required by most local codes.
- Low points in horizontal runs of piping should be provided with condensation traps, as well as condensation drains.
- Piping and mufflers must be properly supported and connected.
- A flexible length of exhaust pipe is required between the engine exhaust manifold and rigid exhaust piping.
- Exhaust piping must be terminated safely outside a structure that houses a generator, in such a way that hot gases and sparks will be discharged harmlessly and will not blow against any combustible surface or material.
- Exhaust piping must not terminate under loading platforms, structures, or near any opening in a building.
- Where necessary, exhaust piping must be guarded and/or insulated to prevent burns.
- Provide a clearance of at least 9 inches (229mm)(10 inches (250mm) recommended) between exhaust piping and any combustible material.
- Keep exhaust piping well clear of fuel tanks, fuel lines, etc.

### 5.3. RAIN CAP

A rain cap is recommended on the end of the exhaust pipe. The rain cap is attached to the end of the pipe and opens due to the pressure from the exhaust discharge force. The rain cap protects the exhaust system from the environment when the system is not running.

### 5.4. SPARK ARRESTOR

Use of a spark arrestor is required by the U.S. Department of Forestry if located on lands under their jurisdiction. The spark arrestor is recommended in areas where combustible materials may ignite such as dry grass, leaves, or other combustible materials.



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## 6. INSTALLATION CHECKLIST BATTERY INSTALLATION

☐ Battery is connected properly.
☐ Recommended battery is installed.
☐ Cables are clean and tight.
☐ Terminals are coated with anti-corrosion grease, and terminal covers are positioned.

### FUEL SYSTEM

☐ Complies with local and NFPA codes.
☐ Fuel is connected and checked for leaks.
☐ Correct fuel pressure (11-14 inches of water (0.6 psi) at all load ranges).
☐ Load block adjusted for maximum power for natural gas fuel.

### LOCATION

☐ Unit is fastened to the appropriate mounting pad.
☐ Louvers are free from obstruction.
☐ Exhaust is clear of flammable objects and debris.

### ELECTRICAL CONNECTIONS

☐ Complies with local code requirements and all National Electrical Codes.
☐ Utility is connected and present.
☐ Transfer switch is connected.
☐ All wires running outside of the generator are in NEC-approved conduit. *Note: Utility wires and transfer switch control wires must be in separate conduit.
☐ Unit is grounded to an approved earth ground.

### COOLING AND VENTILATING

☐ All inlets and outlets are free from obstruction.

### OTHER

☐ Verify that the unit is filled to the proper level with the proper break-in oil. Adjust as required.



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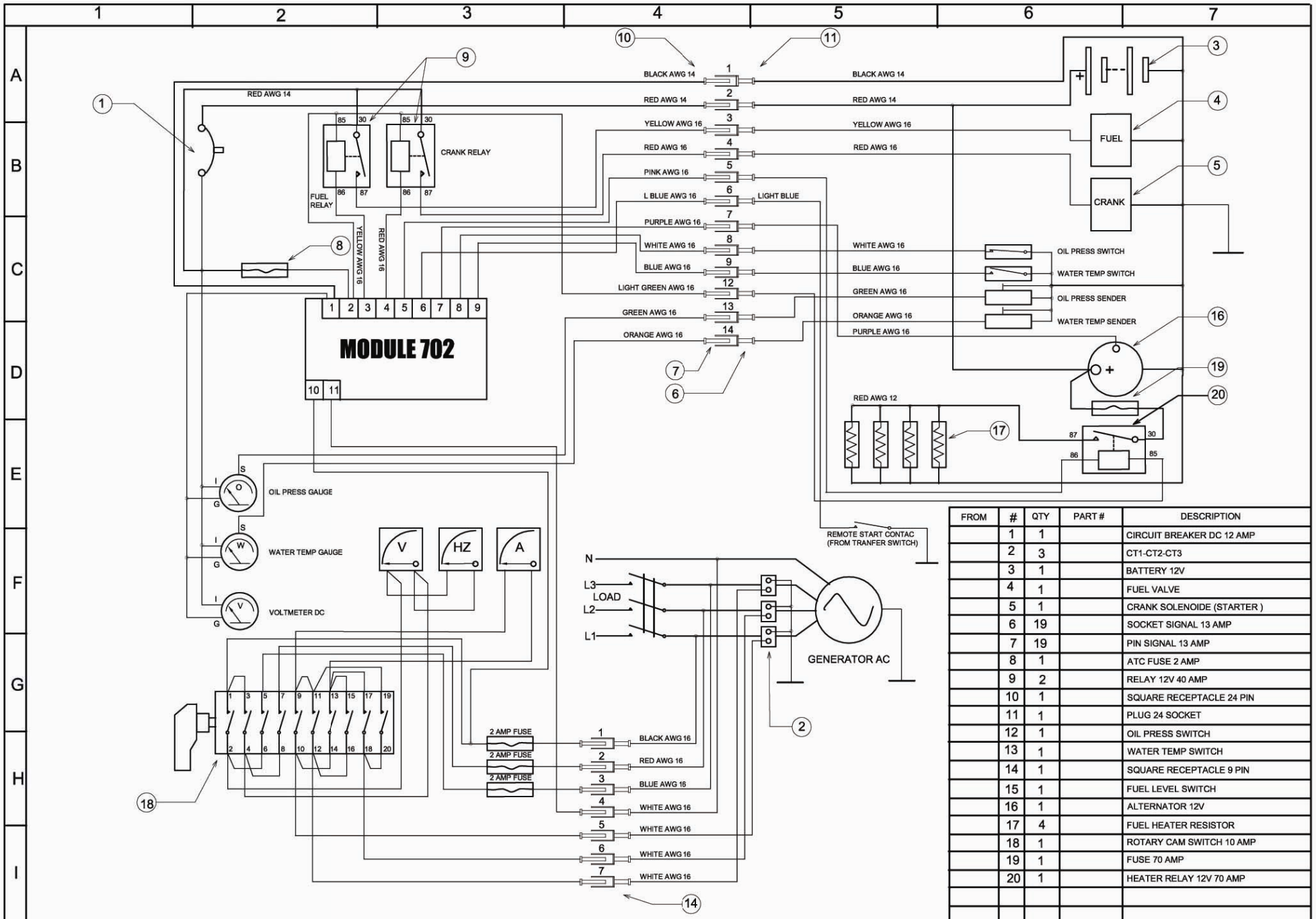


| FROM | # | QTY | PART # | DESCRIPTION |
|---|---|---|---|---|
| | 1 | 1 | | CIRCUIT BREAKER DC 12 AMP |
| | 2 | 3 | | CT1-CT2-CT3 |
| | 3 | 1 | | BATTERY 12V |
| | 4 | 1 | | FUEL VALVE |
| | 5 | 1 | | CRANK SOLENOIDE (STARTER ) |
| | 6 | 19 | | SOCKET SIGNAL 13 AMP |
| | 7 | 19 | | PIN SIGNAL 13 AMP |
| | 8 | 1 | | ATC FUSE 2 AMP |
| | 9 | 2 | | RELAY 12V 40 AMP |
| | 10 | 1 | | SQUARE RECEPTACLE 24 PIN |
| | 11 | 1 | | PLUG 24 SOCKET |
| | 12 | 1 | | OIL PRESS SWITCH |
| | 13 | 1 | | WATER TEMP SWITCH |
| | 14 | 1 | | SQUARE RECEPTACLE 9 PIN |
| | 15 | 1 | | FUEL LEVEL SWITCH |
| | 16 | 1 | | ALTERNATOR 12V |
| | 17 | 4 | | FUEL HEATER RESISTOR |
| | 18 | 1 | | ROTARY CAM SWITCH 10 AMP |
| | 19 | 1 | | FUSE 70 AMP |
| | 20 | 1 | | HEATER RELAY 12V 70 AMP |

PROYECT / COSTUMER:

# ARMSTRONG POWER SYSTEM

| ISSUE | | | | |
|---|---|---|---|---|
| | DRAWN | CHECKED | APPVD | 10/25/07 DATE |

DRAWING: FRANCISCO R LOJOS

TITLE: ELECTRICAL FUNCTION CUMMINS

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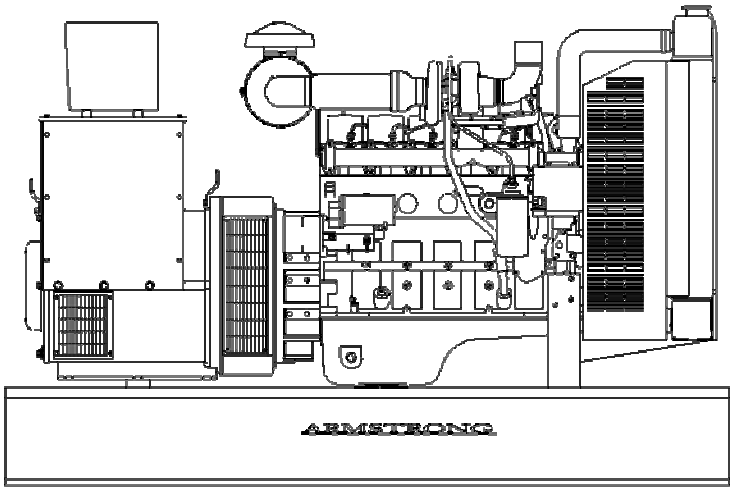
ARMSTRONG
POWER SYSTEMS

# GENERATING SET OPERATION AND MAINTENANCE



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## 6. PRE-OPERATION CHECK

Before starting, complete the following:

1. Set the generator's Start/stop switch to the Stop position.

2. Turn OFF the utility power supply to the transfer switch using the means provided (such as the utility main line circuit breaker).

3. Check the engine crankcase oil level and, if necessary, fill to the dipstick FULL mark with the recommended oil. Do not fill above the FULL mark.

4. Check the fuel supply. All fuel shutoff valves in the fuel supply lines must be open.

**Never operate the engine with the oil level below the "Add" mark on the dipstick. Doing this could damage the engine.**

### 6.1. Electrical Checks.

Complete electrical checks as follows:

1. Turn on the utility power supply to the transfer switch using the means provided (such as a utility main line circuit breaker).

**The transfer switch is now electrically "hot." Contact with "hot" parts will result in extremely hazardous and possibly fatal electrical shock. Proceed with caution.**

2. Use an accurate AC voltmeter to check utility power source voltage across terminals.

3. Check utility power source voltage across terminals and the transfer switch neutral lug; then across second terminal and neutral. Nominal line-to neutral voltage should be 120 volts AC.

4. When certain that utility supply voltage is compatible with transfer switch and load circuit ratings, turn OFF the utility power supply to the transfer switch.

5. Set the generator's main circuit breaker to its OFF (or open) position. Initial tests will be conducted at no-load condition.

6. On the generator panel Start/stop switch to the to start position The engine should crank and start when the remote start input is activated.

7. Let the engine warm up for about five minutes to allow internal temperatures to stabilize. Then, set the generator's main circuit breaker to its ON (or closed) position.

**Proceed with caution! Generator power voltage is now supplied to the transfer switch. Contact with live transfer switch parts will result in dangerous and possibly fatal electrical shock.**

8. Connect an accurate AC voltmeter and an AC frequency meter across transfer switch terminal lugs and voltage and frequency of the unit must be accord to the specifications of the generator.

9. Connect the AC voltmeter test leads across terminal Lugs and neutral, one by one.

10. Set the generator's main circuit breaker to its OFF (or open) position. Let the engine run at no load for a few minutes to stabilize internal engine generator temperatures.

11. Set the generator's Start/stop switch to stop position. The engine should shut down.

NOTE:
It is important that you DO NOT proceed until you are certain that generator AC voltage and frequency are correct and within the stated limits. Generally, if both AC frequency and voltage are high or low, the engine governor requires adjustment. If frequency is correct, but voltage is high or low, the generator's voltage regulator requires adjustment.

### 6.2. GENERATOR TESTS UNDER LOAD

To test the generator set with electrical loads applied, proceed as follows:

1. Set generator's main circuit breaker to its OFF (or open) position.

2. Set the generator's Start/stop switch to OFF.

3. Turn OFF the utility power supply to the transfer switch, using the means provided (such as a utility main line circuit breaker).

**Do not attempt manual transfer switch operation until all power voltage supplies to the transfer switch have been positively turned off. Failure to turn off all power voltage supplies will result in extremely hazardous and possibly fatal electrical shock.**

4. Manually set the transfer switch to the STANDBY position, i.e., load terminals connected to the generator's terminals. The transfer switch operating lever should be down.

5. Set the generator's Start/stop switch to MANUAL. The engine should crank and start immediately.

6. Let the engine stabilize and warm up for a few minutes.

7. Set the generator's main circuit breaker to its ON (or closed) position. Loads are now powered by the standby



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generator.

8. Turn ON electrical loads. Apply an electrical load equal to the full rated wattage/amperage capacity of the installed generator.

9. Connect an accurate AC frequency meter across terminal lugs . Voltage should be +/- 1.5% of the specificated, and frequency +/- 4.0% of the specificated on the unit.

10. Let the generator run at full rated load for 20-30 minutes. Listen for unusual noises, vibration or other indications of abnormal operation. Check for oil leaks, evidence of overheating, etc.

11. When testing under load is complete, turn OFF electrical loads.

12. Set the generator's main circuit breakers to their OFF (or open) positions.

13. Let the engine run at no-load for a few minutes.

14. Set the Start/stop switch to stop. The engine should shut down.

### 6.3. CHECKING AUTOMATIC OPERATION

To check the system for proper automatic operation, proceed as follows:

1. Check that the Start/stop switch is set to stop.

2. Manually set the transfer switch to the UTILITY position, i.e., load terminals connected to the utility power source side.

3. Turn ON the utility power supply to the transfer switch, using the means provided (such as a utility main line circuit breaker).

4. Set the Start/stop switch to manual. The engine should crank and start when the remote start input is activated.

5. Turn OFF the utility power supply to the transfer switch.

With the Start/stop switch at AUTO, the engine should crank and start when the utility source power is turned OFF. After starting, the transfer switch should connect load circuits to the standby side. Let the system go through its entire automatic sequence of operation.

With the generator running and loads powered by generator AC output, turn ON the utility power supply to the transfer switch. The following should occur:

- After about six seconds, the switch should transfer loads back to the utility power source.
- About one minute after retransfer, the engine should shut down.

Check the installation and application data charts for any additional information.



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# INSTALLATION AND APPLICATION

| | Item | Units | Type of Operation and Application | | | |
|---|---|---|---|---|---|---|
| | | | 60 Hz | | 50 Hz | |
| | | | Prime | Standby | Prime | Standby |
| **Engine** | Rated Speed | rpm | 1800 | | 1500 | |
| | Gross Engine Output | bhp (kWm) | 90 (67) | 99 (74) | 77 (58) | 85 (64) |
| | BMEP | psi (kPa) | 165 (1137) | 182 (1255) | 169 (1165) | 187 (1289) |
| | Mean Piston Speed | Ft/s (m/s) | 23.6 (7.2) | | 19.66 (6.0) | |
| **Cooling System** | Ambient Air Temperature | °F (°C) | 122 (50) | | | |
| | Engine Heat Reject to Coolant | BTU/min (kW) | 2035 (35.8) | 2240 (39.3) | 1750 (30.8) | 1995 (35.0) |
| | Coolant Capacity | Gal (L) | 1.9 (7.2) | | | |
| | Standard Thermostat Range | °F (°C) | 180-203 (82-95) | | | |
| | Maximum Pressure Cap | Psi (kpa) | 10 (69) | | | |
| | Maximum coolant friction | Psi (kpa) | 5 (35) | | 4 (28) | |
| **Fuel System** | Total drain flow | gal/h (L/h) | 8 (30) | | | |
| | Fuel Type | | Diesel #2 | | | |
| | Fuel Consumption @ 25% Power | gal/hr (L/hr) | 1.08 | 1.19 | 0.94 | 1.04 |
| | Fuel Consumption @ 50% Power | gal/hr (L/hr) | 2.15 | 2.37 | 1.89 | 2.08 |
| | Fuel Consumption @ 75% Power | gal/hr (L/hr) | 3.23 | 3.56 | 2.83 | 3.12 |
| | Fuel Consumption @ 100% Power | gal/hr (L/hr) | 4.31 | 4.74 | 3.77 | 4.17 |
| **Air Requirement** | Combustion Air Flow | $ft^3$/min (L/s) | 194 (92) | 197 (93) | 141 (66) | 145 (68) |
| | Air Intake Restriction clean filter | In.$H_2O$ (kPa) | 10(2.49) | | | |
| | Air Intake Restriction dirty filter | In.$H_2O$ (kPa) | 25 (6.22) | | | |
| | Exhaust Temperature | °F (°C) | 886 (475) | 934 (501) | 974 (523) | 1035 (557) |
| | Maximun Allowable Back Pressure | In.$H_2O$ (kPa) | 3 (10.13) | | | |
| **Lubrication System** | Maximum oil temperature | °F (°C) | 250 (121) | | | |
| | Oil Pan Capacity | gal (L) | 2.5 (9.5) | | | |
| | Total Engine Oil Cap. w/filter | gal (L) | 2.88 (10.9) | | | |
| | Oil Filter Type | | Cartridge | | | |
| | Lube oil specifications grade | | SAE 15W - 40 | | | |
| **Engine Electricals** | Battery Charging Alternator | Volts, Ground | 12V, negative | | | |
| | Baterry Charging Alternator | Rated amps | 45 | | | |
| | Recommended Battery Cold Crank | CCA amps | 600 | | | |
| | Starter Motor | Volts, Ground | 12V, negative | | | |
| **Operation** | Temperature and Altidtude Losses | % | 4% per 1000 ft (300 m) and 1% per 10°F (2% per 11°C) | | | |



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# INSTALLATION AND APPLICATION

| | Item | Units | Type of Operation and Application | | | |
|---|---|---|---|---|---|---|
| | | | 60 Hz | | 50 Hz | |
| | | | Prime | Standby | Prime | Standby |
| **Engine** | Rated Speed | rpm | 1800 | | 1500 | |
| | Gross Engine Output | bhp (kWm) | 130 (97) | 145 (108) | 117 (87) | 130 (97) |
| | BMEP | psi (kPa) | 239 (1648) | 266 (1838) | 215 (1483) | 239 (1648) |
| | Mean Piston Speed | Ft/s (m/s) | 23.6 (7.2) | | 19.66 (6.0) | |
| **Cooling System** | Ambient Air Temperature | °F (°C) | 122 (50) | | | |
| | Engine Heat Reject to Coolant | BTU/min (kW) | 2633 (46.3) | 2973 (52.2) | 2141 (37.6) | 2423 (42.6) |
| | Coolant Capacity | Gal (L) | 2.1 (7.9) | | | |
| | Standard Thermostat Range | °F (°C) | 180-203 (82-95) | | | |
| | Maximum Pressure Cap | Psi (kpa) | 10 (69) | | | |
| | Maximum coolant friction | Psi (kpa) | 5 (35) | | 4 (28) | |
| **Fuel System** | Total drain flow | gal/h (L/h) | 8 (30) | | | |
| | Fuel Type | | Diesel #2 | | | |
| | Fuel Consumption @ 25% Power | gal/hr (L/hr) | 1.44 | 1.60 | 1.19 | 1.33 |
| | Fuel Consumption @ 50% Power | gal/hr (L/hr) | 2.88 | 3.20 | 2.38 | 2.65 |
| | Fuel Consumption @ 75% Power | gal/hr (L/hr) | 4.31 | 4.79 | 3.58 | 3.98 |
| | Fuel Consumption @ 100% Power | gal/hr (L/hr) | 5.75 | 6.39 | 4.77 | 5.31 |
| **Air Requirement** | Combustion Air Flow | $ft^3$/min (L/s) | 247 (117) | 261 (123) | 169 (80) | 181 (85) |
| | Air Intake Restriction clean filter | In.$H_2O$ (kPa) | 10(2.49) | | | |
| | Air Intake Restriction dirty filter | In.$H_2O$ (kPa) | 25 (6.22) | | | |
| | Exhaust Temperature | °F (°C) | 889 (476) | 919 (501) | 1045 (563) | 1053 (567) |
| | Maximun Allowable Back Pressure | In.$H_2O$ (kPa) | 3 (10.13) | | | |
| **Lubrication System** | Maximum oil temperature | °F (°C) | 250 (121) | | | |
| | Oil Pan Capacity | gal (L) | 2.5 (9.5) | | | |
| | Total Engine Oil Cap. w/filter | gal (L) | 2.88 (10.9) | | | |
| | Oil Filter Type | | Cartridge | | | |
| | Lube oil specifications grade | | SAE 15W - 40 | | | |
| **Engine Electricals** | Battery Charging Alternator | Volts, Ground | 12V, negative | | | |
| | Baterry Charging Alternator | Rated amps | 45 | | | |
| | Recommended Battery Cold Crank | CCA amps | 650 | | | |
| | Starter Motor | Volts, Ground | 12V, negative | | | |
| **Operation** | Temperature and Altidtude Losses | % | 4% per 1000 ft (300 m) and 1% per 10°F (2% per 11°C) | | | |



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# INSTALLATION AND APPLICATION

| | Item | Units | Type of Operation and Application | | | |
|---|---|---|---|---|---|---|
| | | | 60 Hz | | 50 Hz | |
| | | | Prime | Standby | Prime | Standby |
| **Engine** | Rated Speed | rpm | 1800 | | 1500 | |
| | Gross Engine Output | bhp (kWm) | 155 (115) | 170 (127) | 130 (97) | 143 (107) |
| | BMEP | psi (kPa) | 189 (1308) | 208 (1435) | 159 (1097) | 175 (1207) |
| | Mean Piston Speed | Ft/s (m/s) | 23.6 (7.2) | | 19.66 (6.0) | |
| **Cooling System** | Ambient Air Temperature | °F (°C) | 122 (50) | | | |
| | Engine Heat Reject to Coolant | BTU/min (kW) | 3640 (64) | 3950 (69) | 3080 (54) | 3450 (61) |
| | Coolant Capacity | Gal (L) | 2.4 (9.1) | | | |
| | Standard Thermostat Range | °F (°C) | 180-203 (82-95) | | | |
| | Maximum Pressure Cap | Psi (kpa) | 10 (69) | | | |
| | Maximum coolant friction | Psi (kpa) | 5 (35) | | 4(28) | |
| **Fuel System** | Total drain flow | gal/h (L/h) | 8 (30) | | | |
| | Fuel Type | | Diesel #2 | | | |
| | Fuel Consumption @ 25% Power | gal/hr (L/hr) | 1.88 | 2.06 | 1.57 | 1.73 |
| | Fuel Consumption @ 50% Power | gal/hr (L/hr) | 3.75 | 4.12 | 3.15 | 3.46 |
| | Fuel Consumption @ 75% Power | gal/hr (L/hr) | 5.63 | 6.18 | 4.72 | 5.20 |
| | Fuel Consumption @ 100% Power | gal/hr (L/hr) | 7.51 | 8.24 | 6.30 | 6.93 |
| **Air Requirement** | Combustion Air Flow | $ft^3$/min (L/s) | 315 (150) | 325 (153) | 230 (109) | 240 (113) |
| | Air Intake Restriction clean filter | In.$H_2O$ (kPa) | 10(2.49) | | | |
| | Air Intake Restriction dirty filter | In.$H_2O$ (kPa) | 25 (6.22) | | | |
| | Exhaust Temperature | °F (°C) | 955 (513) | 995 (535) | 1025 (552) | 1080 (582) |
| | Maximun Allowable Back Pressure | In.$H_2O$ (kPa) | 3 (10.13) | | | |
| **Lubrication System** | Maximum oil temperature | °F (°C) | 250 (121) | | | |
| | Oil Pan Capacity | gal (L) | 3.8 (14.2) | | | |
| | Total Engine Oil Cap. w/filter | gal (L) | 4.3 (16.4) | | | |
| | Oil Filter Type | | Cartridge | | | |
| | Lube oil specifications grade | | SAE 15W - 40 | | | |
| **Engine Electricals** | Battery Charging Alternator | Volts, Ground | 12V, negative | | | |
| | Baterry Charging Alternator | Rated amps | 45 | | | |
| | Recommended Battery Cold Crank | CCA amps | 650 | | | |
| | Starter Motor | Volts, Ground | 12V, negative | | | |
| **Operation** | Temperature and Altidtude Losses | % | 4% per 1000 ft (300 m) and 1% per 10°F (2% per 11°C) | | | |



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# INSTALLATION AND APPLICATION

| | Item | Units | Type of Operation and Application | | | |
|---|---|---|---|---|---|---|
| | | | 60 Hz | | 50 Hz | |
| | | | Prime | Standby | Prime | Standby |
| **Engine** | Rated Speed | rpm | 1800 | | 1500 | |
| | Gross Engine Output | bhp (kWm) | 188 (140) | 207 (154) | 164 (122) | 181 (135) |
| | BMEP | psi (kPa) | 230 (1587) | 253 (1747) | 201 (1384) | 221 (1527) |
| | Mean Piston Speed | Ft/s (m/s) | 23.6 (7.2) | | 19.66 (6.0) | |
| **Cooling System** | Ambient Air Temperature | °F (°C) | 122 (50) | | | |
| | Engine Heat Reject to Coolant | BTU/min (kW) | 4205 (73.9) | 4534 (79.7) | 3587 (63) | 3843 (67.5) |
| | Coolant Capacity | Gal (L) | 2.6 (9.9) | | | |
| | Standard Thermostat Range | °F (°C) | 180-203 (82-95) | | | |
| | Maximum Pressure Cap | Psi (kpa) | 10 (69) | | | |
| | Maximum coolant friction | Psi (kpa) | 5 (35) | | 4 (28) | |
| **Fuel System** | Total drain flow | gal/h (L/h) | | | | |
| | Fuel Type | | Diesel #2 | | | |
| | Fuel Consumption @ 25% Power | gal/hr (L/hr) | 2.30 | 2.54 | 2.01 | 2.22 |
| | Fuel Consumption @ 50% Power | gal/hr (L/hr) | 4.61 | 5.07 | 4.02 | 4.44 |
| | Fuel Consumption @ 75% Power | gal/hr (L/hr) | 6.91 | 7.61 | 6.03 | 6.65 |
| | Fuel Consumption @ 100% Power | gal/hr (L/hr) | 9.21 | 10.15 | 8.04 | 8.87 |
| **Air Requirement** | Combustion Air Flow | $ft^3$/min (L/s) | 391 (181) | 409 (190) | 284 (135) | 302 (144) |
| | Air Intake Restriction clean filter | In.$H_2O$ (kPa) | 10(2.49) | | | |
| | Air Intake Restriction dirty filter | In.$H_2O$ (kPa) | 25 (6.22) | | | |
| | Exhaust Temperature | °F (°C) | 947 (508) | 991 (533) | 1041 (560) | 1073 (578) |
| | Maximun Allowable Back Pressure | In.$H_2O$ (kPa) | 40.78 (10.15) | | | |
| **Lubrication System** | Maximum oil temperature | °F (°C) | 250 (121) | | | |
| | Oil Pan Capacity | gal (L) | 3.8 (14.2) | | | |
| | Total Engine Oil Cap. w/filter | gal (L) | 4.3 (16.4) | | | |
| | Oil Filter Type | | Cartridge | | | |
| | Lube oil specifications grade | | SAE 15W - 40 | | | |
| **Engine Electricals** | Battery Charging Alternator | Volts, Ground | 12V, negative | | | |
| | Baterry Charging Alternator | Rated amps | 55 | | | |
| | Recommended Battery Cold Crank | CCA amps | 800 / 0 °F – 18 °C | | | |
| | Starter Motor | Volts, Ground | 12V, negative | | | |
| **Operation** | Temperature and Altidtude Losses | % | 4% per 1000 ft (300 m) and 1% per 10°F (2% per 11°C) | | | |



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# INSTALLATION AND APPLICATION

| | Item | Units | Type of Operation and Application | | | |
|---|---|---|---|---|---|---|
| | | | 60 Hz | | 50 Hz | |
| | | | Prime | Standby | Prime | Standby |
| **Engine** | Rated Speed | rpm | 1800 | | 1500 | |
| | Gross Engine Output | bhp (kWm) | 252 (188) | 277 (207) | 219 (163) | 241 (180) |
| | BMEP | psi (kPa) | 219 (1512) | 241 (16620 | 190 (1314) | 209 (1446) |
| | Mean Piston Speed | Ft/s (m/s) | 26.57 (8.1) | | 22.31 (6.8) | |
| **Cooling System** | Ambient Air Temperature | °F (°C) | 122 (50) | | | |
| | Engine Heat Reject to Coolant | BTU/min (kW) | 6055 (107) | 6630 (117) | 4695 (83) | 5415 (95) |
| | Coolant Capacity | Gal (L) | 3.25 (12.3) | | | |
| | Standard Thermostat Range | °F (°C) | 180-203 (82-95) | | | |
| | Maximum Pressure Cap | Psi (kpa) | 10 (69) | | | |
| | Maximum coolant friction | Psi (kpa) | 5 (35) | | 4(28) | |
| **Fuel System** | Maximum fuel flow | gal/h (L/h) | 55 (208) | | | |
| | Fuel Type | | Diesel #2 | | | |
| | Fuel Consumption @ 25% Power | gal/hr (L/hr) | 3.20 | 3.52 | 2.69 | 2.96 |
| | Fuel Consumption @ 50% Power | gal/hr (L/hr) | 6.41 | 7.04 | 5.38 | 5.92 |
| | Fuel Consumption @ 75% Power | gal/hr (L/hr) | 9.61 | 10.56 | 8.07 | 8.88 |
| | Fuel Consumption @ 100% Power | gal/hr (L/hr) | 12.81 | 14.08 | 10.76 | 11.85 |
| **Air Requirement** | Combustion Air Flow | $ft^3$/min (L/s) | 540 (255) | 550 (259) | 407 (192) | 437 (206) |
| | Air Intake Restriction clean filter | In.$H_2O$ (kPa) | 10(2.49) | | | |
| | Air Intake Restriction dirty filter | In.$H_2O$ (kPa) | 25 (6.22) | | | |
| | Exhaust Temperature | °F (°C) | 955 (513) | 1055 (569) | 996 (536) | 1046 (563) |
| | Maximun Allowable Back Pressure | In.$H_2O$ (kPa) | 3 (10.13) | | | |
| **Lubrication System** | Maximum oil temperature | °F (°C) | 250 (121) | | | |
| | Oil Pan Capacity | gal (L) | 5.0 (18.9) | | | |
| | Total Engine Oil Cap. w/filter | gal (L) | 6.3 (23.8) | | | |
| | Oil Filter Type | | Cartridge | | | |
| | Lube oil specifications grade | | SAE 15W - 40 | | | |
| **Engine Electricals** | Battery Charging Alternator | Volts, Ground | 12V, negative | | | |
| | Baterry Charging Alternator | Rated amps | 55 | | | |
| | Recommended Battery Cold Crank | CCA amps | 1200 / 0 °F – 18 °C | | | |
| | Starter Motor | Volts, Ground | 12V, negative | | | |
| **Operation** | Temperature and Altidtude Losses | % | 4% per 1000 ft (300 m) and 1% per 10°F (2% per 11°C) | | | |



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# INSTALLATION AND APPLICATION

| | Item | Units | Type of Operation and Application | | | |
|---|---|---|---|---|---|---|
| | | | 60 Hz | | 50 Hz | |
| | | | Prime | Standby | Prime | Standby |
| **Engine** | Rated Speed | rpm | 1800 | | 1500 | |
| | Gross Engine Output | bhp (kWm) | 285 (213) | 317 (237) | 245 (183) | 272 (203) |
| | BMEP | psi (kPa) | 248 (1710) | 276 (1902) | 213 (1470) | 237 (1632) |
| | Mean Piston Speed | Ft/s (m/s) | 26.57 (8.1) | | 22.30 (6.8) | |
| **Cooling System** | Ambient Air Temperature | °F (°C) | 122 (50) | | | |
| | Engine Heat Reject to Coolant | BTU/min (kW) | 4250 (74) | 4725 (83) | 4090 (72) | 4420 (78) |
| | Coolant Capacity | Gal (L) | 3.25 (12.3) | | | |
| | Standard Thermostat Range | °F (°C) | 180-203 (82-95) | | | |
| | Maximum Pressure Cap | Psi (kpa) | 10 (69) | | | |
| | Maximum coolant friction | Psi (kpa) | 5 (35) | | 4(28) | |
| **Fuel System** | Maximum fuel flow | gal/h (L/h) | 55 (208) | | | |
| | Fuel Type | | Diesel #2 | | | |
| | Fuel Consumption @ 25% Power | gal/hr (L/hr) | 3.39 | 3.77 | 2.89 | 3.21 |
| | Fuel Consumption @ 50% Power | gal/hr (L/hr) | 6.78 | 7.55 | 5.78 | 6.42 |
| | Fuel Consumption @ 75% Power | gal/hr (L/hr) | 10.18 | 11.32 | 8.67 | 9.63 |
| | Fuel Consumption @ 100% Power | gal/hr (L/hr) | 13.57 | 15.09 | 11.56 | 12.83 |
| **Air Requirement** | Combustion Air Flow | $ft^3$/min (L/s) | 610 (289) | 666 (314) | 425 (200) | 465 (220) |
| | Air Intake Restriction clean filter | In.$H_2O$ (kPa) | 10(2.49) | | | |
| | Air Intake Restriction dirty filter | In.$H_2O$ (kPa) | 25 (6.22) | | | |
| | Exhaust Temperature | °F (°C) | 886 (474) | 920 (493) | 1037 (553) | 1059 (571) |
| | Maximun Allowable Back Pressure | In.$H_2O$ (kPa) | 3 (10.13) | | | |
| **Lubrication System** | Maximum oil temperature | °F (°C) | 250 (121) | | | |
| | Oil Pan Capacity | gal (L) | 5.0 (18.9) | | | |
| | Total Engine Oil Cap. w/filter | gal (L) | 6.3 (23.8) | | | |
| | Oil Filter Type | | Cartridge | | | |
| | Lube oil specifications grade | | SAE 15W - 40 | | | |
| **Engine Electricals** | Battery Charging Alternator | Volts, Ground | 12V, negative | | | |
| | Baterry Charging Alternator | Rated amps | 55 | | | |
| | Recommended Battery Cold Crank | CCA amps | 1200 / 0 °F – 18 °C | | | |
| | Starter Motor | Volts, Ground | 12V, negative | | | |
| **Operation** | Temperature and Altidtude Losses | % | For 1800 RPM: 4% per 1000 ft (300 m) and 3.3% per 10°F (6% per 10°C)<br>For 1500 RPM: 4% per 1000 ft (300 m) and 8.3% per 10°F (15% per 10°C) | | | |



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## 7. CONTROL PANEL OPERATION

### 7.1. DESCRIPTION OF OPERATION

#### 7.1 .1 MANUAL MODE OPERATION

To initiate a start sequence in **MANUAL**, turn the key to the position.

To start the set, press the button. Preheating will begin, indicated by the LED.

> NOTE:- There is no Start Delay in this mode of operation. Starting will commence as soon as the start button is pressed.

The **Fuel Solenoid** is energised, then the **Starter Motor** is engaged.

The engine is cranked for a 10-second period. If the engine fails to fire during this cranking attempt then the starter motor is disengaged for a 10-second period. Should this sequence continue beyond the 3 starting attempts, the start sequence will be terminated and **Fail to Start** fault will be illuminated.

When the engine fires, the starter motor is disengaged and locked out at 20 Hz measured from the Alternator output. After the starter motor has disengaged, the **Safety On** timer is activated (which is fixed at 10 seconds), allowing Oil Pressure, High Engine Temperature, Under-speed and Charge Fail to stabilise without triggering the fault.

Selecting **STOP** de-energises the **FUEL SOLENOID**, bringing the generator to a stop.

#### 7.1..2 AUTOMATIC MODE OF OPERATION

To initiate a start sequence in **AUTO**, turn the key to the position.

The start sequence is initiated when the remote start input is activated. After a fixed 5 second start delay, Preheating will occur (fixed at 10s) , indicated by the LED.

The **Fuel Solenoid** is energised, then one second later, the **Starter Motor** is engaged.
The engine is cranked for a 10-second period. If the engine fails to fire during this cranking attempt then the starter motor is disengaged for a 10-second rest period. Should this sequence continue beyond the 3 starting attempts, the start sequence will be terminated and **Fail to Start** fault will be illuminated.

When the engine fires, the starter motor is disengaged and locked out at 20 Hz measured from the Alternator output.. After the starter motor has disengaged, the **Safety On** timer is activated, allowing Oil Pressure, High Engine Temperature, Under-speed and Charge Fail to stabilise without triggering the fault. On removal of the **Remote Start** signal the **Stop** delay timer is initiated. Once this timer has expired the **Fuel Solenoid** is de-energised, bringing the generator to a stop.

#### 7.1.3 WARNINGS

Warnings are used to warn the operator of an impending fault **BATTERY CHARGE FAILURE**, if the module does not detect a voltage from the warning light terminal on the auxiliary charge alternator, the icon will illuminate.

#### 7.1.4 SHUTDOWNS

Shutdowns are latching and stop the Generator. The alarm must be cleared, and the fault removed to reset the module. In the event of a shutdown the appropriate LED will be illuminated NOTE:- The alarm condition must be rectified before a reset will take place. If the alarm condition remains it will not be possible to reset the unit (The exception to this is the Low Oil Pressure alarm and similar 'delayed alarms', as the oil pressure will be low with the engine at rest).

**FAIL TO START**, if the engine does not fire after the pre-set 3 attempts at starting, a shutdown will be initiated. The icon will illuminate.

**LOW OIL PRESSURE**, if the module detects that the engine oil pressure has fallen below the low oil pressure switch after the **Safety On** timer has expired, a shutdown will occur. The icon will illuminate.

**HIGH ENGINE TEMPERATURE** if the module detects that the engine coolant temperature has exceeded the high engine temperature switch after the **Safety On** timer has expired, a shutdown will occur. The icon will illuminate.

**OVERSPEED**, if the engine speed exceeds the pre-set trip (14% above the nominal frequency) a shutdown is initiated. Overspeed is not delayed, it is an **immediate shutdown.** The icon will illuminate.

> NOTE:- During the start-up sequence the overspeed trip level is extended to 24% above the normal frequency for the duration of the safety timer to allow an extra trip level margin. This is used to prevent nuisance tripping on start-up.

**UNDERSPEED**, if the engine speed falls below 20Hz (fixed)



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after the **Safety On** timer has expired, a shutdown is initiated. The icon will flash.

NOTE:- The icon is used to indicate both underspeed and overspeed. A flashing icon indicates underspeed. A steady icon indicates overspeed.

## 7.2. SETTINGS

### 7.2.1 FIXED SETTINGS

The following settings are factory set and are NOT adjustable.

| | |
|---|---|
| Crank disconnect | 20Hz |
| Underspeed | 20Hz |
| Overspeed | 57Hz (50Hz nominal)<br>68 Hz (60Hz nominal) |
| Remote start delay | 5s |
| Preheat | 10s |
| Crank period | 10s |
| Crank rest | 10s |
| Safety delay | 10s |
| Remote stop delay | 30s |

## 7.3 TERMINAL DESCRIPTION

| PIN No | DESCRIPTION | CABLE SIZE | NOTES |
|---|---|---|---|
| **1** | DC Plant Supply Input (-ve) | **1.0mm** | Connected to plant battery negative |
| **2** | DC Plant Supply Input (+ve) | **1.0mm** | Connected to plant battery positive (Recommended Fuse 2A) |
| **3** | Fuel relay Output | **0.5mm** | Used to operate the fuel solenoid control relay. |
| **4** | Start relay Output | **0.5mm** | Used to operate the cranking control relay. |
| **5** | Preheat Output relay | **0.5mm** | Used to operate the preheat control relay. |
| **6** | Remote Start Input | **0.5mm** | Switch to negative to start set. |
| **7** | Charge Fail Input/ Excitation Output | **1.0mm** | Must NOT be connected to plant supply negative if not used. |
| **8** | Low Oil Pressure Input | **0.5mm** | Switch to negative on fault. |
| **9** | High Engine Temp Input | **0.5mm** | Switch to negative on fault. |

NOTE:- All the outputs are solid state, rated at 1.2 Amps 8 Volts to 35 Volts DC, and switch to battery negative when active.



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### 7.4. INSTRUMENTS READING

Additional to the digital module, the control panel has analog capabilities hat provide more durability and low maintenance cost.

Those instruments are:

- Amperes meter
- Volt meter
- Frequency meter
- Temperature meter
- Oil pressure level
- Battery charge meter.

To check the readings of volts, amperes ad frequency of each phase the control panel has a toggle switch that will allow to change between the readings of each phase.

When it is on he of position no lecture will be received. Position number 1 will give the readings of the phase L1, position number 2, will give the readings of the phase L2, and position number 3 will give the reading of the phase L3 only on 3 phase equipments. Single phase equipments will give no reading on this position.

## 8. ENGINE

### 8.1. CHECKS DURING OPERATION

While running, make the following checks to see that all parts are working correctly.

**Radiator Cooling water (Coolant)**

To avoid personal injury:

- Do not remove radiator cap until coolant temperature is well below its boiling point. Then loosen cap slightly to the stop position, to relieve any pressure, before removing cap completely.

When the engine overheats and hot coolant overflows through the overflow pipe and cannot be stopped, stop the engine immediately and make the following checks to determine the cause of trouble:

1. Check to see if there is any coolant leak;
2. Check to see if there is any obstacle around the cooling air inlet or outlet;
3. Check to see if there is any dirt or dust between radiator fins and tube;
4. Check to see if the fan belt is too loose;
5. Check to see if radiator water pipe is clogged; and
6. Check to see if anti-freeze is mixed into coolant in warm seasons.

**Fuel**

To avoid personal injury:

• Fluid escaping from pinholes may be invisible. Do not use hands to search for suspected leaks; Use a piece of cardboard or wood, instead, If injured by escaping fluid, see a medical doctor at once. This fluid can produce gangrene or a severe allergic reaction.

• Check any leaks from fuel pipes or fuel injection pipes. Use eye protection when checking for leaks. Be careful not to empty the fuel tank. Otherwise air may enter the fuel system, requiring fuel system bleeding.

While the engine is run within the rated output range:

• The color of exhaust remains colorless.

• If the output slightly exceeds the rated level, exhaust may become a little colored with the output level kept constant.

• If the engine is run continuously with dark exhaust emission, it may lead to trouble with the engine.

• Immediately stop the engine if;

• The engine suddenly slow down or accelerates.

• Unusual noises suddenly appear.

• Exhaust fumes suddenly become very dark.

### 8.2. MAINTENANCE SCHEDULE

Perform maintenance at whichever interval that occurs first. At each scheduled maintenance interval, perform all previous maintenance checks that are due for scheduled main-



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tenance.

**Daily or Refueling - Maintenance Check(4)**

- Air Intake Piping - Inspect
- Air Tank and Reservoirs - Drain
- Cooling Fan - Check/Correct
- Crankcase Breather Tube - Inspect
- Drive Belts - Check/Correct
- Engine Coolant Level - Check/Correct
- Engine Lubricating Oil Level - Check/Correct
- Fuel-Water Separator - Drain

**Every 250 Hours or 3 Months - Maintenance Check (1, 4)**

- Air Cleaner Restriction - Check/Correct
- Air Compressor Mounting Hardware - Check/Correct
- Charge Air Cooler - Check/Correct
- Charge Air Piping - Check/Correct
- Fuel Injection Pump Mounting Hardware - Check/Correct
- Lubricating Oil and Filters - Change
- Radiator Hoses - Check

**Every 500 Hours or 6 Months - Maintenance Check (2, 3, 4)**

- Engine Coolant - Antifreeze Check
- Fuel Filter, Canister-Type - Replace
- Fuel Filter, Spin-on-Type - Replace
- Lubricating Oil and Filters - Change

**Every 1000 Hours or 1 Year - Maintenance Check (4)**

- Cooling Fan Belt Tensioner - Check/Correct
- Fan Hub, Belt-Driven - Check/Correct
- Overhead Set - Adjust

**Every 2000 Hours or 2 Years - Maintenance Check (3, 4)**

- Air Compressor Discharge Line - Check/Correct
- Cooling System - Drain, Flush, and Fill
- Vibration Damper, Rubber - Check
Vibration Damper, Viscous - Check

1. NOTE: The lubricating oil and lubricating oil filter interval can be adjusted based on application, fuel consumption, gross vehicle weight, and idle time. For engines whose aspiration is jacket water-cooled, turbocharged only, or natural, refer to Table in the Oil Drain Intervals section.
2. The lubricating oil and lubricating oil filter interval can be adjusted based on application, fuel consumption, gross vehicle weight, and idle time. For engines whose aspiration is charge air cooled, refer to Table in the Oil Drain Intervals section.
3. Antifreeze check interval is every oil change or 500 hours or 6 months, whichever occurs first. The operator must use a heavy-duty year-round antifreeze that meets the chemical composition of GM6038M. The antifreeze change interval is 2 years, 2000 hours, or whichever occurs first. Antifreeze is essential for freeze, overheat, and corrosion protection.
4. Follow the manufacturer's recommended maintenance procedures for the starter, alternator, generator, batteries, electrical components, charge air cooler, radiator, air compressor, air cleaner, refrigerant compressor, and fan clutch. Refer to the Component Manufacturers in Section M.



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| Table 1: Jacket Water Cooled, Turbocharged Only, or Naturally Aspirated Engines | | | |
|---|---|---|---|
| Cummins Engine Standard Classification | American Petroleum Institute Classification | International Classifications | All Engine Ratings |
| (CES) | (API) | | |
| CES-20078, CES-20077, CES-20076, CES-20072, CES-20071 | API CI-4/SK, API CI-4, API CH-4, API CH-4/SJ | ACEA E-5, Global DHD-1 | 250 Hours or 3 Months |
| CES-20075 | API CF-4/SG | ACEA E-3, ACEA E-2, JAMA DH-1 | 150 Hours or 6 Weeks |
| | API CG-4/SH, API CD, API CE | ACEA E-1 | Obsolete. Do**not** use. |

| Table 2: Charge Air Cooled Engines | | | |
|---|---|---|---|
| Cummins Engine Standard Classification | American Petroleum Institute Classification | International Classifications | All Engine Ratings |
| (CES) | (API) | | |
| CES-20078, CES-20077, CES-20076, CES-20072, CES-20071 | API CI-4/SK, API CI-4, API CH-4, API CH-4/SJ | ACEA E-5, Global DHD-1 | 500 Hours or 6 Months |
| CES-20075 | API CF-4/SG | ACEA E-3, ACEA E-2, JAMA DH-1 | 250 Hours or 3 Weeks |
| | API CG-4/SH, API CD, API CE | ACEA E-1 | Obsolete. Do**not** use. |

### 8.3. CUMMINS/FLEETGUARD® FILTER SPECIFICATIONS

Fleetguard® is a subsidiary of Cummins Inc. Fleetguard® filters are developed through joint testing at Cummins and Fleetguard®. Fleetguard® filters are standard on new Cummins engines. Cummins Inc. recommends their use.

Fleetguard® products meet all Cummins Source Approval Test standards to provide the quality filtration necessary to achieve the engine's design life. If other brands are substituted, the purchaser should insist on products that the supplier has tested to meet Cummins high-quality standards.

Cummins can not be responsible for problems caused by non-genuine filters that do not meet Cummins performance or durability requirements.

| Filter Part Numbers | | | | | | |
|---|---|---|---|---|---|---|
| | Lubricating Oil Filter B3.9 | Lubricating Oil Filter B4.5 | Lubricating Oil Filter B5.9 | Fuel Filter B3.9 | Fuel Filter B4.5 | Fuel Filter B5.9 |
| Cummins Part Number | 3934429 | 3934429 | 3934430 | 3966139 | 3991350 | 3900632 |
| Fleetguard® Part Number | LF9100 | LF9100 | LF9098 | FF9413 | FS19608 | FF9417 |



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# WARNING

Do not mix gasoline, alcohol, or gasohol with diesel fuel. This mixture can cause an explosion.

# CAUTION

Due to the precise tolerances of diesel injection systems, it is extremely important that the fuel be kept clean and free of dirt or water. Dirt or water in the system can cause severe damage to both the fuel pump and the fuel injectors.

Cummins Inc. recommends the use of ASTM number 2D fuel. The use of number 2 diesel fuel will result in optimum engine performance.
At operating temperatures below 0°C [32°F], acceptable performance can be obtained by using blends of number 2D and number 1D.
NOTE: Lighter fuels can reduce fuel economy.

NOTE: Engines equipped with diesel particulate filters require the use of diesel fuel with 30 ppm sulfur maximum. There are no acceptable substitutes.

The viscosity of the fuel **must** be kept above 1.3 cSt at 40°C [104°F] to provide adequate pumping and lubricating characteristics to fuel system components.
The following chart lists acceptable substitute fuels for this engine.

Acceptable Substitute Fuels

| Number 1D Diesel(1) (2) (3) | Number 2D Diesel(3) | Number 1K Kerosene | Jet-A | Jet-A1 | JP-5 | JP-8 | Jet-B | JP-4 | CITE |
|---|---|---|---|---|---|---|---|---|---|
| A | OK | **Not** OK | A | A | A | A | **Not** OK | **Not** OK | **Not** OK |

An "A" means OK **only** if fuel lubricity is adequate. This means the BOCLE number is 3100 or greater as measured by ASTM specification D6078, Scuffing Load Ball On Cylinder Evaluator (SLBOCLE). Lubricity can also be measured by ASTM, specification D6079, ISO 12156, High Frequency Reciporating Rig (HFRR) in which the fuel **must** have a wear scar diameter of 0.45 mm [0.02 in] or less.

Any adjustment to compensate for reduced performance with a fuel system using alternate fuel is **not** warrantable.

Winter blend fuels, such as found at commercial fuel-dispensing outlets, are combinations of number 1D and 2D diesel fuels and are acceptable.

# CAUTION

A sulfated ash limit of 1.85 percent has been placed on all engine lubricating oils recommended for use in Cummins engines. Higher ash oils can cause valve and/or piston damage and lead to excessive oil consumption.

# CAUTION

The use of a synthetic-base oil does not justify extended oil change intervals. Extended oil change intervals can decrease engine life due to factors such as corrosion, deposits, and wear.



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The use of quality engine lubricating oils, combined with appropriate oil drain and filter change intervals, is a critical factor in maintaining engine performance and durability.
Cummins Inc. recommends the use of high-quality SAE 15W-40 heavy-duty engine oil, such as Valvoline® Premium Blue®, which meets performance specifications as listed below.

| Cummins Engineering Standard Classification (CES) | American Petroleum Institute Classification (API) | International Classifications | Comments |
|---|---|---|---|
| | API CD API CE API CG-4/SH | ACEA E-1 | **OBSOLETE. DO NOT USE.** |
| CES-20075 | API CF-4/SG | ACEA E-2 ACEA E-3 JAMA DH-1 | Minimum acceptable oil classification for midrange engines. |
| CES-20071 CES-20076 | API CH-4/SJ API CH-4 | Global DHD-1 | Acceptable oil classification for midrange engines. |
| CES-20072 CES-20077 | API CH-4 | ACEA E-5 Global DHD-1 | Similar in performance to CES-20071 but validated under European test standards. Excellent oil for midrange engines. |
| CES-20078 | API CI-4/SK API CI-4 | | Excellent oil for midrange engines. |

NOTE: In areas where CH-4/SJ or CG-4/SH oils are not available, refer to Oil Drain Intervals in Section 2.
A sulfated ash limit of 1.0 mass percent is suggested for optimum valve and piston deposit and oil consumption control.

As the engine oil becomes contaminated, essential oil additives are depleted. Lubricating oils protect the engine as long as these additives are functioning properly. Progressive contamination of the oil between oil and filter change intervals is normal. The amount of contamination will vary depending on the operation of the engine, kilometers or miles on the oil, fuel consumed, and new oil added.

Extending oil and filter change intervals beyond the recommendations will decrease engine life due to factors such as corrosion, deposits, and wear.

Special “break-in” engine lubricating oils are not recommended for new or rebuilt Cummins engines. Use the same type of oil during the break-in as is used in normal operation.

The use of low-viscosity oils, such as 10W or 10W-30, can be used to aid in starting the engine and in providing sufficient oil flow at ambient temperatures below -5°C [23°F]. However, continuous use of low-viscosity oils can decrease engine life due to wear. Refer to the accompanying chart.

If an engine is operated in ambient temperatures consistently below -23°C [-9°F] and there are no provisions to keep the engine warm when it is not in operation, use a synthetic CH/SI or CH/SK or higher API classification engine oil with adequate low-temperature properties such as 5W-20 or 5W-30.

The oil supplier is responsible for meeting the performance service specifications represented with its product.

Use low-silicate antifreeze that meets ASTM4985 (GM6038M specification) criteria. Fully formulated coolant must meet ASTM D-6210/D-6211. Cummins Inc. recommends using either a 50/50 mixture of good-quality water and fully formulated antifreeze, or fully formulated coolant when filling the cooling system.

Good-quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chlorides and sulfates cause cooling system corrosion.



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| Water Quality | |
|---|---|
| Calcium Magnesium (hardness) | Maximum 170 ppm as ($CaCO_3$ + $MgCO^3$) |
| Chloride | 40 ppm as (Cl) |
| Sulfur | 100 ppm as ($SO_4$) |

Cummins Inc. recommends using Fleetguard® Compleat. It is available in both glycol forms (ethylene and propylene). Fully formulated antifreeze must be mixed with good-quality water at a 50/50 ratio (40- to 60-percent working range). A 50/50 mixture of antifreeze and water gives a -36°C [-33°F] freezing point and a 108°C [226°F] boiling point, which is adequate for locations in North America. The actual lowest freezing point of ethylene glycol antifreeze is at 68 percent. Using higher concentrations of antifreeze will raise the freezing point of the solution and increase the possibility of a silica gel problem.

Do not use sealing additives in the cooling system. The use of sealing additives will:

- Buildup in coolant low-flow areas
- Plug the radiator and oil cooler Possibly damage the water pump seal.

Do **not** use soluble oils in the cooling system. The use of soluble oils will:

- Corrode brass and copper
- Damage heat transfer surfaces
- Damage seals and hoses.

## 9. ALTERNATOR

For safety purposes it is necessary that any testing or maintenance carried out on electrical machine are performed by qualified and authorized personnel, and all operation must be performed when the machine is stopped, at ambient temperature and disconnected from any supply source (including the auxiliary circuits such as the anti-condensation heaters). **Furthermore all measures must be taken to avoid restarting the gen-set during maintenance.**

### 9.1. INSPECTION AND MAINTENACE INTERVALS

Inspection and maintenance should take into account the importance of the plant ambient conditions (dust etc.) and operating conditions.
As a general rule, the machine should be subjected to a first inspection after approx. 500 operating hours (in any case not more than 1 year) and subsequent inspections when performing maintenance on prime mover.
When performing inspection check that:

- The generator operates smoothly, without noise or irregular vibrations due to bearing deterioration
- The operating data complies with that detailed on the rating plate
- The air inlet openings are not obstructed
- The supply cables show no signs of deterioration and connections are firmly tight
- The electrical connections are in perfect condition (undamaged)
- Screws and nuts are firmly tightened.

### 9.2. MAINTENNCE OF BEARINGS

The lifetime of bearings is determined by multiple factors and specifically by:

- The lifetime of the grease. ·
- The environmental conditions and working temperature.
- The external loads and vibrations.

The bearings (D.E. and N.D.E. side are prelubricated sealed type (life lubrication), with sufficient grease quantity for a long operating
time.
The life expected time is, in case of normal operating condition, of about 20000 hours for all bearings.



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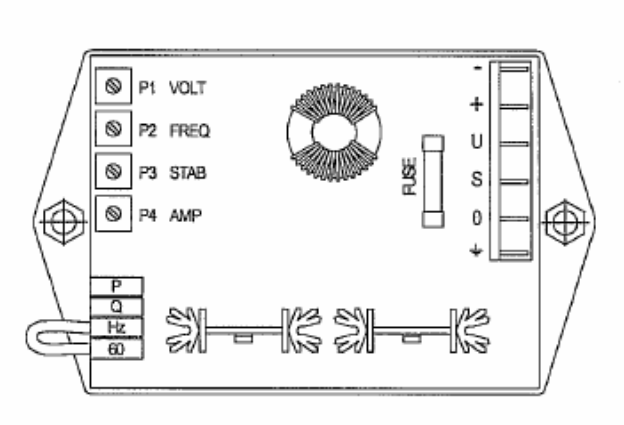
In case of complete overhaul of genset, the bearing of the generator should be changed.
On request prelubricated bearings with regreasing system can be mounted. When regreasing use 20/ 30 grams of grease.
Following types of grease are to be recommended for normal application:

MOBIL OIL: MOBILUX 3
SHELL: ALVANIA 3
AGIP: GR MW 3
ESSO: BEACON 3

### 9.3. VOLTAG REGULATOR




The generators are provided with automatic voltage regulator. The AVR is provided with potentiometers to adapt the characteristics of the AVR to different operating conditions.

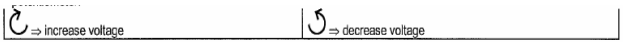
The AVR is provided with adjustable stability circuitry to allow operations in a wide range of applications.

The AVR is equipped also with protecting circuit allowing the generator to operate underspeed if not loaded.

ATTENTIONI: it is not advisable to have the generator operating loaded when the frequency (speed) is below the rated value: this kind of operation is an overload for the whole generator excitation system.

CONNECTION OF AVR
The AVR is connected to the terminals of the generator and to exciter FAST-ON terminals.

USE OF POTENTIOMETERS




P1/VOLT- Potentiometer for adjusting the output voltage of the generator; it allows a wide range of voltage setting (i.e. between 350 and 470 V; or between 170 and 260 V depending on winding connections)). When resetting the potentiometer, the voltage has to be set in the range +5%,-5% around the rated voltage of the machine. In order to obtain a finer regulation, or to adjust the voltage from control panel or to limit the voltage range, it is possible to insert an external potentiometer.

P2/FREQ- Potentiometer for changing the low speed protection. Usually it is set in order to reduce the excitation when the speed is 10 % below the rated value at 50 Hz. By removing the bridge which is normally shorting the auxiliary terminals 60-Hz of the regulator, the low speed protection acts properly for 60 Hz.

P3/STAB- Potentiometer for stability adjust. By rotating it clockwise the stability of the regulator increases, but the response time becomes longer.

P4/AMP- Potentiometer for chancing the overexcitation limit device. The overexcitation limit device helps to protect the excitation system. This device is delayed to avoid transitory conditions (in case of overexcitation).

On the AVR there is a protecting fuse. In case it should be necessary to replace it, high speed fuses should be used; in addition they should have high breaking resistance with a rated voltage of 500V, and rated current of 10A. The AVR is connected to the terminals of the generator and to exciter using FAST—ON terminals.

**ARMTRONG POWER SYSTEMS**

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